DOCUMENT RESUME

ED 433 206 SE 062 366

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TITLE High School and College Student Perceptions of the Ozone Depletion Problem.
PUB DATE 1998-11-05
NOTE 7p.; Paper presented at the Annual Meeting of the Mid-South Education Research Association (New Orleans, LA, November 5, 1998).
PUB TYPE Reports - Research (143)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Air Pollution; Graduate Students; High School Students; Higher Education; Science Education; *Student Attitudes; Undergraduate Students

ABSTRACT

This paper examines the knowledge of high school biology students (n=107), undergraduate elementary education majors (n=42), and graduate students in an advanced elementary science methods course (n=22) about ozone depletion. The questionnaire used contained 30 items pertaining to ozone depletion which were divided into three subscales: (1) results of ozone depletion; (2) causes of ozone depletion; and (3) ways to alleviate ozone depletion. Results are analyzed according to the different groups studied: suburban high school students, urban high school students, undergraduate students, and graduate students. (CCM)

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High School and College Student Perceptions of the Ozone Depletion Problem

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Paper presented to the Mid-South Education Research Association Convention, New Orleans, Louisiana, November 5, 1998

SE 059 346

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INTRODUCTION

Environmental issues are an important topic both in national news and in science education. From previous studies, data have revealed that students bear many misconceptions relating to the issues of global warming, ozone depletion, and acid rain (Boyes et al. 1995; Groves & Pugh, 1999). Currently, students are exposed to these issues in their (K-12) science classes and at several points during the college years, and these issues are also addressed on television. According to Adler (1992), such sources of information may be filled with misconceptions, and Potts, et al. (1996) point out that such information sources are unidirectional as well, which allows for little testing of ideas. Because these environmental problems are very complex, and often interrelate in many ways, this complexity can lead to misunderstandings among students as well as the general public.

Environmental science misconceptions may arise from incorrect instruction given by teachers who do not have correct understandings of these phenomena themselves. Arons, et al. (1994) conducted a study that included elementary level, physical science, and geography preservice teachers that identified several misconceptions about atmospheric phenomena. Gomez-Granell and Cervera-March (1993) found superficial knowledge of environmental concepts and a lack of understanding of causal connections in high school and college age students. Such findings increased our concern about the ability of teachers to instruct their own students correctly if they did not have the proper understandings themselves. Thus, this question of incorrect instruction formed the basis for our research study, in which we examined the knowledge concerning ozone depletion held by high school students, college students, and graduate students.

Methods

The 171 subjects of this study consisted of 57 high school biology students (grades 9-12) in a suburban school and 50 in an urban school, 42 undergraduate elementary education majors, and 22 graduate students in an advanced elementary science methods course. The questionnaire contained 30 items pertaining to ozone depletion which was divided into three subscales: 1) results of ozone depletion, 2) causes of ozone depletion, and 3) ways to alleviate ozone depletion. The questionnaire was administered to all groups during the 1998 spring semester, and data were analyzed using ANOVA and t-tests for subscale totals and individual items.

Results

An item-by-item comparison of the high school students showed no major differences in responses overall for the two schools. However, the two schools were significantly different on three items, but the reason for this is not known. These three items are:

#4- If the ozone hole becomes worse, there will be more water pollution.
#24-The ozone hole can be alleviated by stopping use of CFC gases.
#25-The ozone hole can be alleviated by planting more trees.

Analysis of variance revealed several significant differences between the groups for each subgroup of the questionnaire. For subscale #1, (results of ozone depletion), both college student groups scored higher than the two sets of high school students ($p. < .05$), but were not significantly different from each other. Subscale #2 targeted causes of the ozone problem. The only significant difference was between the graduate students and the urban high schools ($p. < .05$). With regard to ways of alleviating the ozone problem, subscale #3, the preservice teachers scored significantly higher than did the high school students ($p. < .05$).

Responses were analyzed according to how many items were answered correctly by 70% or more, or by 30% or less, of the participants in each group. The urban high school group had no items which were chosen correctly by 70% or more students; the suburban high school group had five items which met this criteria. The preservice teachers had four items which met the criteria, and the graduate students had five. Four of these items were held in common by the suburban high school group and the two college groups:

#7- If the ozone hole becomes worse, there will be changes in the world's weather.
#10- If the ozone hole becomes worse, more ultraviolet rays will reach the earth's surface.
#13- The ozone hole is made worse by too much ultraviolet light reaching the earth's surface.
#24- The ozone hole can be lessened by stopping the use of CFC gases.

Item #10 and #13 both relate to ultraviolet light, and #24 focuses on CFC gases. The issues of CFC's and ultraviolet light both appear in the popular media, and in many elementary and high school level science textbooks. Just how reduction in the ozone layer (#7) will effect the world's weather is problematic, but many researchers agree that some effects are possible. For example, increased UV radiation may reduce carbon uptake by plankton, which would add to the carbon dioxide entering the atmosphere. However, even if it happens, the effect of ozone layer depletion on weather is not direct. At any rate, 70% or more of the participants in these three groups were able to respond correctly to these items, and this is encouraging, but the number of items which generated scores lower than 30% is discouraging. The four groups shared eight items for which scores were all lower than 30%.

#8- If the ozone hole becomes worse, the world's ice caps will shrink in size.
#12- The ozone hole is made worse because too much carbon dioxide is entering the atmosphere.
#18- The ozone hole is made worse by gas from artificial fertilizers.
#15- The ozone hole is made worse by gases from rotting wastes.
#16- The ozone hole is made worse by radioactive waste from nuclear power.
#21- The ozone hole can be alleviated by using nuclear instead of coal power stations.
#26- The ozone hole can be alleviated by recycling household trash.

#27- The ozone hole can be alleviated by producing less carbon dioxide and methane

Poor performance on these items reveals confusion between global warming and ozone depletion, and a misconception that the cause of one problem is also the cause of the other. Likewise, the students assumed that ways to alleviate one problem will necessarily help with the other. Also, responses to #16 suggest a general conflation of cause and effect involving radioactive wastes and other environmental problems; that since this is a dangerous problem, then control of it will produce improvement in other (unrelated) environmental problems (Groves and Pugh), 1999; Boyes et al, 1993).

Both of the two high school groups scored lower than 30% on 20 items, or 67% of the total set of items. The preservice teachers had 10 items lower than 30%, and the graduate students had 13. These results show that the lack of clear understanding of the ozone depletion problem is serious, even though performance improves between high school and college. The graduate students and the suburban high school group scored 77% on item #5 regarding the relationship between ozone depletion and skin cancer. This problem has been reported in popular magazines, newspapers, and on television, so it's not surprising that this score is relatively high, but it still shows that over 20% of the participants do not recognize this dangerous effect of ozone depletion.

Items that generated the highest scores for each group were:

#7- 95% for the graduate students
#10- 82% and 68% for the suburban and urban high schools, respectively, and 95% for the graduate students
#24- 93% for the preservice teachers

The scores for items 10 and 24 show that many participants are aware that UV rays and CFC gases play a role in the ozone depletion problem. The response to #7 is high for the graduate students, but when the scores for #1, #8, and #15 are taken into account, the possibility is that the participants answered correctly but for the wrong reason arises. The effect of ozone depletion on weather is indirect and subtle, while factors involving global warming (the topic of #1, #8, and #15) are more direct. Thus, it is possible that the participants had in mind that ozone depletion would produce the same results as global warming through buildup of greenhouse gases.

Items that generated the lowest scores were:

#1- 2% and 6% for the suburban high schools respectively, and 9% for the graduate students
#8- 9% for the graduate students
#15-10 % for the preservice teachers

Each of these items deals with global warming, a well-known issue. Research by Groves and Pugh, (1999) and Boyes et al., (1993) found that high school and college students conflate cause and effect relationships of this problem with that of other environmental problems, just as they do with the ozone depletion problem. Such results for two different environmental issues indicates

with the ozone depletion problem. Such results for two different environmental issues indicates that such confusion over cause/effect relationships, and measures needed to alleviate these problems, is widespread. Students have a general awareness of environmental issues, but they have little specific knowledge of them, and information gained through print and television media is often simplistic and misleading (Adler, 1992). Thus, they mistakenly assume relationships between the various environmental problems that do not in fact exist. Hills (1989) argues that often these misunderstandings arise because people do not have sufficient exposure to information to be able to develop sound understandings of such complex issues. Thus, the real problem in this case is lack of information, rather than incorrect concepts. But, if they are given proper exposure to information about these issues, then they can begin to develop solid concepts. A pilot test by Groves and Pugh involving the greenhouse effect (unpublished data) showed that a one hour intervention involving constructivist teaching strategies was sufficient to produce some significant long-term gains in student understanding. Several items on that questionnaire, similar to the ones used for this study, did not show a gain in understanding, however. But, these initial results do provide evidence that some long-term learning occurred. That the major area of improvement was only on results of the greenhouse effect, with little gain for causal relationships, is a point of concern, and may indicate the blocking effect of incorrect prior concepts. If this is the case, then a radical change in the students' conceptual system is needed (Posner et al. 1982), and such a change would very likely be resistant to the effects of a short intervention. Boyes et al. (1995) noted that:

> In the realm of global environmental problems at least, all forms of anthropogenic 'pollution' are seen as exacerbating all environmental problems and, conversely, all 'environmentally friendly' actions are seen as benefiting all aspects of the environment. (p. 143)

Implications for Teaching

Many elementary teachers hold serious misconceptions about the ozone depletion problem due to both lack of knowledge of the subject, and to incorrect understanding of the cause/effect relationships involved. As a result, a short interactive lesson on this environmental issue may produce some gains in understanding, but will likely leave incorrect ideas regarding cause/effect relationships untouched. Thus, both Hills (1989) and Gomez-Granell and Cervera-March (1993) are partly correct. Of these two instructional problems, the latter is more serious, for it is the passing along of misconceptions by teachers that is worrisome. Incorrect concepts developed by students in the elementary and middle school years may become resistant to change in high school and college. Therefore, the next step in this research will be to test an instructional intervention which focuses on conceptual change.

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